Electronics

3-in-1 local network links personal computers

Arcnet, Ethernet, and Cluster/One techniques team up to expand small-net scheme with new capabilities

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☐ Instead of settling for just one local-network technique, a new system integrates elements of three different networks: Arcnet, Ethernet, and Cluster/One. The first provides the basic token-passing network, the second adds the internetworking software, and the third supplies the software of a net based on personal computers.

Three systems are better than one in this case because of the need for a smooth transition from the small, proprietary networks of today to larger networks that can keep up with the growth of personal computing in business and other professional applications. The new PLAN (personal local-area network) 4000 system is therefore designed to support around 10 times as much data traffic as most low-cost, personal-computer nets.

Cost-effective net

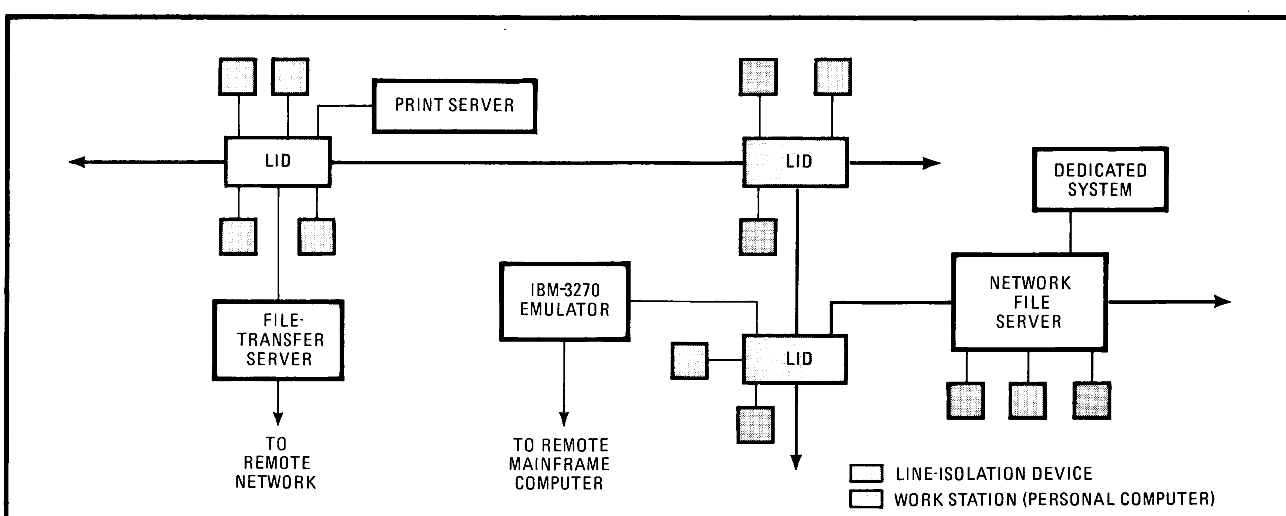
PLAN can expand to any size that may be needed, and it will support the development of corporate-wide networks containing a variety of network types and computing resources. Yet it adds little to the cost of personal computers and starts out with software already proven on such machines.

The PLAN system currently links Apple II, Apple III and IBM Personal Computers into networks containing work stations and file, print, and communications servers (Fig. 1). As a server-based net, the intelligence is distributed among the various work stations and similar computers (servers) performing such functions as file and printer management for the net. Thus there is no central host computer, as in some other networks.

Most of the server programs and other software for data sharing, remote communications, and electronic mail previously ran on Apple computers in Cluster/One networks. It now runs on Personal Computer operating systems as well, so that all three computer types can operate in a single network.

Revised servers

There are are also a new file-server subsystem and new IBM-3270 and -3780 terminal emulators. The file server expands network-wide, shared-data capacity to more than 500 megabytes per server and has multiple ports for directly connecting other facilities. The original gateway-server program now links PLAN segments together into networks larger than the standard Arcnet limit of 255 nodes and approximately 4 miles. It also interconnects Cluster/One networks with PLAN nets and will support interconnection of other networks, such as Ethernet. Cluster/One applications can be upgraded to PLAN networks without software modification by adding the new



1. Star-burst. Clusters of Apple and IBM Personal Computer work stations and servers are linked into subnetworks and connected to a high-performance file server. All connections are made through line-isolation devices that also identify any malfunctioning nodes.

THREE LOCAL NETWORKS COMPARED			
Specification	**Cluster/One**	**PLAN**	**Ethernet**
Maximum data rate (Mb/s)	0.24	2.5	10
Transmission mode	baseband	baseband	baseband
Number of nodes	64	255	1,024
Transmission medium	16-wire ribbon or twisted pair	coaxial cable	coaxial cable
Topology	any	star-burst	linear bus
Access method	carrier-sense multiple-access with collision avoidance	token passing	carrier-sense multiple-access with collision detection
Network length (ft)	1,000	22,000	7,600
Station connection costs	$400	$595	$1,000 and up

interface hardware and software enhancements.

In effect, a valuable house that has taken more than three years to build—the Cluster/One software—has been moved to a new foundation that provides more facilities. Such upgrades are needed to support the growth of resource-sharing communities in business and other professional applications of personal computers. The server-based type of system has become popular in resource-sharing applications during the last few years, but the proprietary designs necessary in the past to reduce network costs have generally limited them to small networks. The work stations of the Cluster/One system, for example, execute proprietary data-link protocols in software and support only one vendor's computers (Apple). The complex software interface limits data rate and expandability (see table, above).

In the PLAN adaptation of the Arcnet system, the network interface is a custom set of three integrated circuits supported by Ethernet software handling internetwork data communications and transport functions The ICs handle link functions; for instance, work stations use the Arcnet broadcast mode (transmission to all nodes) to locate a file server containing the programs needed to activate user operating systems.

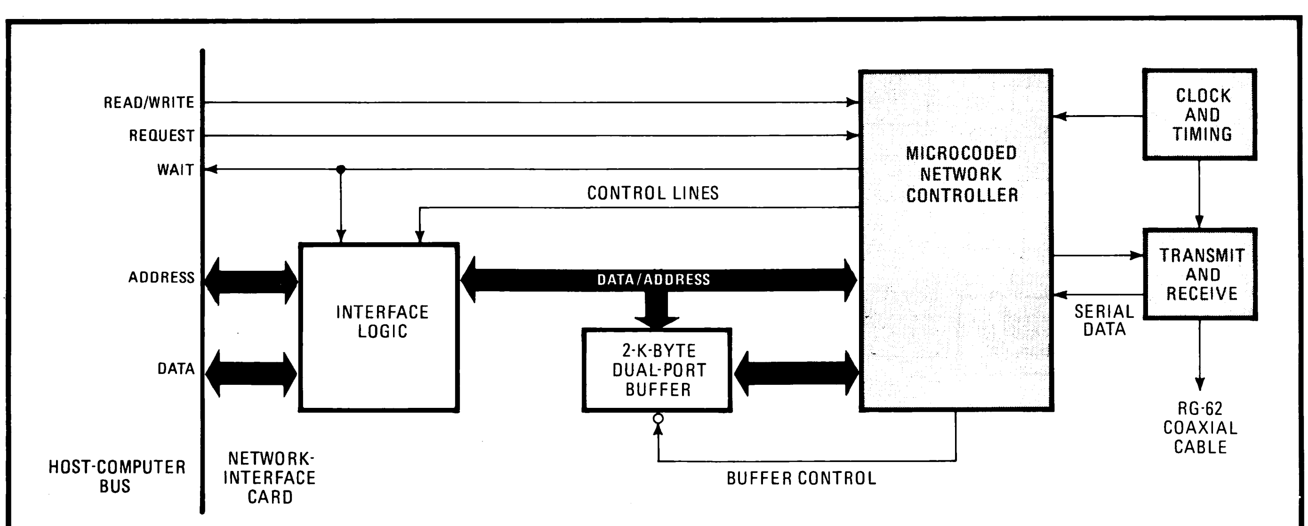
The chip set, located on the work-station and server computers' network-interface cards, includes a high-speed custom MOS controller that implements the network algorithm in microcode at high speed (Fig. 2). Because custom chips are used, the computer-connection cost is below $700—a cost that includes the per-computer share of the line-interface hardware. The coaxial cable is also inexpensive—RG-62 with twist-on connectors. Compatible with IBM-3270 terminal systems and standard in Arcnet systems, it is already installed in more than a million offices.

This basic network setup corresponds to the first four layers of the International Standards Organization's open systems interconnection reference model for multilayer computer-network architectures (Fig. 3). The cabling, line-isolation devices and interface ICs form the physical and data-link layers, which handle data transmission, arbitration (in token passing, each node must wait for its turn to transmit), and intranetwork addressing. The network and transport software performs such functions as internetwork addressing and routing, interprocess communications and transmission error control.

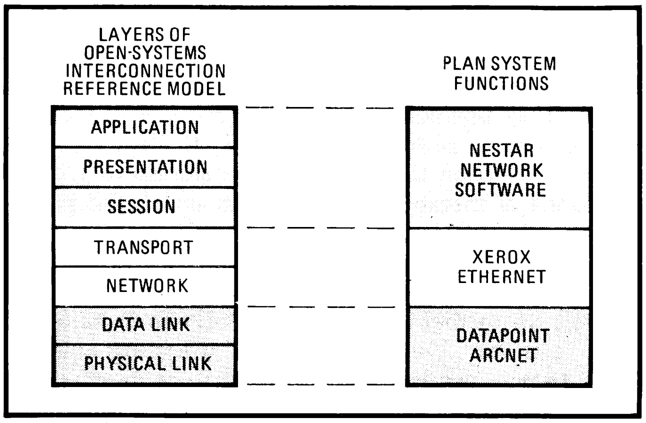
Logical choices

Arcnet and Ethernet implementations of these layers were chosen because they are becoming *de facto* standards for high-performance networks. A transition to such standards is highly desirable in order to eliminate current limitations on multivendor support for low-cost networks and to expedite the integration of these systems with other nets.

Arcnet interface specifications were made available about a year ago by Datapoint Corp., San Antonio, Texas, which also helped Standard Microsystems Corp., Hauppauge, N. Y., develop an MOS large-scale IC for general use (the custom chip set devised for the PLAN net was derived from this design). At about the same time, Xerox Corp., Stamford, Conn., published the high-level, Xerox Network System (XNS) internet transport proto-



2. Network interface. Custom chip set (color) on network-interface card implements the network algorithm and interfaces the cable. The three chips form an Arcnet interface that is supported by Ethernet high-level protocols executed in software by the computer.



3. Stacked up. Overall system design parallels multilayer architecture recommended by the International Standards Organization. An Arcnet-compatible interface forms the bottom layers, Xerox internet transport protocols the next two, and Nestar software the rest.

cols—the ones that are used in the PLAN system.

The PLAN system employs Arcnet, rather than Ethernet data-link protocols, because the former's token-passing technique is simpler and more efficient, reduces interface logic costs, and provides a topology well suited to the way personal-computer networks are organized. However, the XNS internet transport protocols were chosen for the network and transport software layers because they are the best-defined and most powerful in the public domain and correspond to the proposed ISO network and transport architectures.

These Xerox protocols are the key to the overall upgrade of Cluster/One because they are essentially independent of the lower-level data-link protocols and the type of application-oriented services, such as terminal emulation and server operation, provided by the higher layers. In effect, they allow the existing software to be reconnected to the underlying utilities with little change. Another major advantage is that other upper-layer software systems written to the XNS protocols can be added to the PLAN system as well. Further, this choice will simplify development of PLAN-Ethernet gateways, an important consideration for users who envision hybrid systems. The network and transport functions are utilized automatically by the file, print, and communication servers, so the operating details can be ignored by users. However, PLAN software library modules make them accessible for development by equipment manufacturers and users of specialized servers and custom station-to-station communication techniques.

Software choices

The rest of the network's system software extends up to the ISO application layer, which consists of servers, electronic-mail services, and the like. PLAN application software includes such general-purpose programs as Multi-Calc, a network version of the VisiCalc spreadsheet program, and the NPL (for nonprocedural language) data-based management system from Desktop Software. What's more, other applications programs are available from Nestar-supported software companies.

Although customized, the PLAN interface is hardware-compatible with the interfaces in Datapoint's minicomputer-based Arcnet networks and has the same performance. In fact, performance evaluations published by Datapoint demonstrate that even in very large networks, which require many token-passing operations, several hundred messages per second can be transmitted successfully [*Electronics*, Sept. 8, 1982, p. 158].

Most small local nets depend for cost reduction on simplified, low-speed versions of carrier-sense, multiple-access (CSMA) data-link protocols. Cluster/One employs a software form of CSMA/CD (CSMA with collision detection) known as CSMA/CA (collision avoidance). The changeover from such protocols to token passing can produce a greater increase in overall network performance than is indicated by the increase in raw data rate (to 2.5 megabits a second), because of the efficiency of the Arcnet protocols in heavily populated networks.

Matching Ethernet

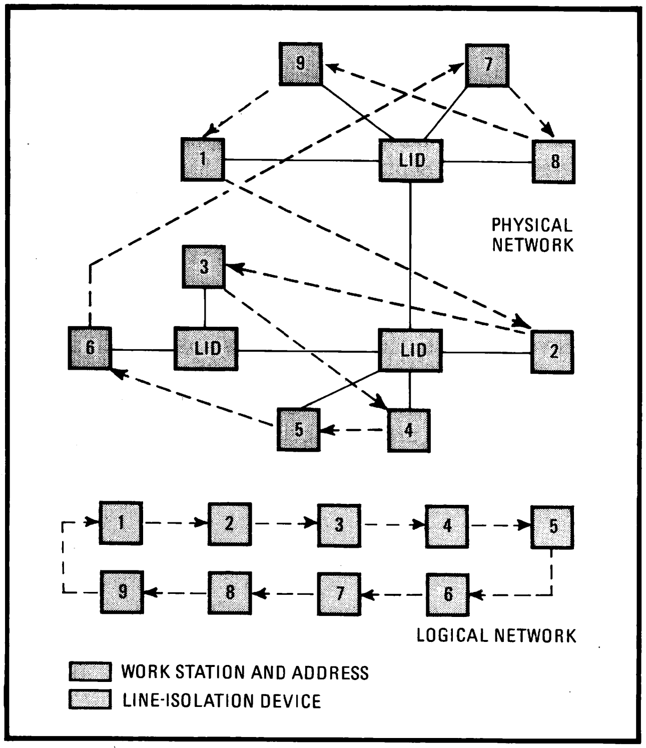
Moreover, token passing compares favorably with Ethernet CSMA/CD hardware-based network control, despite its relatively low cost. One major advantage is that the token (the logical invitation to transmit a message) goes from node to node in a specified sequence. This arrangement guarantees that a node can transmit a message within a particular time interval, so a system designer can calculate a precise, worst-case transmission delay. Also, before a node starts actual data transmission, it can check the receiving node to ensure that buffer space will be available for its message, which prevents wasting traffic capacity on useless transmissions.

The token passes between nodes in 28 microseconds, and a message takes 113 μs plus 4.4 μs for each byte of data. A node can transmit one packet of data when it receives the token. A packet contains up to 253 data bytes, preceded by source and destination identifications and followed by cyclic-redundancy-check bytes.

Ethernet data links have no token-passing intervals and theoretically may operate at data rates to 10 Mb/s. Also, the CSMA/CD protocol allows any node to transmit whenever the network is free. However, it also allows an unlimited number of collisions and retries, which makes the delay indeterminate, a disadvantage in real-time applications. Ethernet systems can utilize only a small fraction of the theoretical traffic capacity because of the need to hold down the number of transmission collisions and, thus, keep the number and retries from multiplying.

A token-passing network utilizes traffic capacity efficiently because time is not spent in resolving those access contentions. As important for low-cost designs, the interface costs much less because the logic is simpler and the data rate is moderate. CSMA/CD requires considerable logic to detect collisions, back off, and try again. Also, since token-passing keeps the network contention-free, with only a single node transmitting at a time and in one direction, signal amplification is unidirectional rather than bidirectional. This feature contributes to the low connection cost of PLAN.

The PLAN system is a multicluster network. For instance, the star-like clusters in Fig. 1 could each be in a separate business department within a single building or on a corporate campus. Arcnet specifications allow a segment (basic network) to extend about four miles



4. Logical ring. Token-passing sequence converts the star-burst topology into a logical ring that makes the physical connections easier to organize. Additional work stations can be connected to any of the line-isolation devices to extend the logical ring.

(20,000 feet) and contain 255 nodes. PLAN networks can be further extended by gateway servers—personal computers that host an internetworking program.

Token passing makes it easy to organize the work stations and servers. It creates a logical ring within the star-burst physical topology (Fig. 4). A logical ring's physical topology is effectively arbitrary—that is, the token is simply passed to the next higher address, wherever that station is physically located on the network. New stations may be added anywhere without reorganizing addresses. A physical ring, with transmission sequence determined by actual node locations, would make it difficult or inefficient to extend a network over several floors of a building, for example.

In the PLAN system, network-interface cards in each work station or server take the place of Arcnet resource-interface modules, and line-isolation devices correspond to the main Arcnet cable-connection points (hubs). Each cluster (star) is formed by connecting RG-62 cable between the interface cards and the ports of the associated isolation unit. The clusters are then interconnected by RG-62 runs between isolation units.

These line-isolation devices may have 10, 20, or 30 connection ports. They condition signals being transmitted from a node to the rest of the network, terminate the cables, and include transformers to isolate electrical noise at each end of a cable run. Cables are not tapped between the terminations, so that signal noise cannot be generated by multiple signal reflections. Nor can a noisy node disrupt the overall network because the isolation units fully buffer the nodes.

Most network communications will revolve around the new file server and its resident file-processing and management programs. Cluster/One file servers are dedicated Apple II 64K models with peripheral disk and tape drives. They upgrade to PLAN file servers but have only 8-bit computer performance. The PLAN file server is a proprietary design that allows shared storage to grow to thousands of megabytes. Also, it can match the performance of 8-, 16-, and 32-bit computers.

Based on an 8-megahertz MC68000 with 256-K bytes of random-access memory, the new file server buffers and controls up to four 137-megabyte (formatted) hard-disk drives and four 20- or 45-megabyte streaming tape-cartridge backup drives. One of each of these units is integrated with the processor and memory in a cabinet. Three expansion units bring the total disk capacity to more than 500 megabytes. Two or more of these conglomerations can be connected to each network so that it can reach up to gigabyte capacities.

Making connections

The server contains a 30-port line-isolation device as well as the standard interface for net-wide communications. The isolation device directly connects the server to as many 29 work stations, other servers, or remote isolation units. Besides facilitating network start-up, this arrangement makes it possible to create special subnetworks with directly connected equipment.

This resident file-management program employs a variable-size, logical volume for efficient use of storage and handles backup, password protection, error checking, and retransmission. Other system programs are supported on the personal-computer operating systems: PC-DOS 1.1 and the UCSD p-System for the IBM Personal Computer; DOS 3.2.1, Apple Pascal 1.1, and CP/M 2.2 for the Apple II; and Apple II emulator mode and SOS 1.1 native mode for the Apple III.

The various network programs are integrated so they can be employed as a system for such application services as electronic mail. With the file transfer server, work stations can send files or entire volumes to remote PLAN networks, Cluster/One nets, or stand-alone personal computers. The transfer program supports standard and automatic-dialing modems and can record all linking and transfer operations. The Messenger (electronic mail) service also handles related functions, like logging the time of day, scheduling, filing, sorting, printing, and unattended operation. The print server produces hard copy on a priority basis or overnight.

The IBM-3270 and -3780 terminal emulators support terminal-to-terminal communications and remote job entry, for transactions with mainframe data bases and batch processing. Moreover, the internetworking gateway server supports real-time communications between different segments of extended PLAN networks. To connect a Cluster/One network to a PLAN net requires a gateway server: an Apple computer containing both network interfaces and the gateway-server program. Likewise, gateways to other networks will require suitable hardware interfaces, such as an Ethernet controller, and software translation of any non-XNS protocols. However, the network and transport software library should simplify translator development. □

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